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SUCCESS OF SEEDING NATIVE GRASSES AFTER A HOLOCAUSTIC FIRE[1]

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INTRODUCTION

Areas of holocaustic wildfires traditionally have been seeded to provide soil stability and to restore nutrient cycling (Tiedemann and Klock 1973, Stephenson 1979 pers. comm.). Such a holocaustic fire was the extensive La Mesa fire which was ignited June 16, 1977 in the vicinity of Bandelier National Monument, which is located in north-central New Mexico. Because of the severity of the fire and the need to protect valuable archeological resources (Fletcher 1979 pers. comm.), to prevent severe erosion of the highly erodable volcanic soil, and to reduce flash flooding, the area was seeded with native grass. The success of the germination of seeded species as related to several parameters was studied.

STUDY AREA

The La Mesa fire was located in the Santa Fe National Forest and Bandelier National Monument of the Jemez Mountains

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on the Pajarito Plateau. This plateau is an extension of the eastern flanks of the Jemez Mountains located approximately 35 miles (56 km) northwest of Santa Fe, New Mexico. The area has an arid to semiarid climate with an average of 15-17 inches (41 cm) of precipitation most of which falls during the months of July and August, often in heavy but short rainstorms.

The topography of the area is variable; gently to moderately sloping mesas are separated by precipitous canyons many of which are 700-800 feet (213-244 m) deep. The plateau is volcanic in origin. Soils are shallow on the mesa tops, deeper in depressed areas, and moderately deep to deep in the canyon bottoms. The mesa top areas are easily erodable (Earth Environmental Consultants, Inc. 1974).

The plateau is archeologically rich with over 600 ruins, the protection of which was an incentive for the establishment of Bandelier National Monument in 1916.

The La Mesa fire consumed over 15,270 acres (6180 h) of forested land with most of the area burned severely. The fire was ignited on National Forest land in old slash from which it moved onto Bandelier National Monument and Department of Energy land of Los Alamos Scientific Laboratory. Although the majority of the fire burned within the ponderosa pine association it also consumed acreage in pinyon-juniper and mixed conifer.

METHODS

An effort to rehabilitate the burned area was begun July 9, 1977 (24 days after ignition of the fire). The objective was to

maintain soil stability and on-site soil productivity as well as to maintain the water quality of the watershed. At the request of the National Park Service only native species were utilized. Thus, the area was seeded with six grass species including sand dropseed (Sporobolus cryptandrus), spike muhly (Muhlenbergia wrightii), western wheatgrass (Agropyron smithii), slender wheatgrass (Agropyron trachycaulum), sheep fescue (Festuca ovina), and blue grama (Bouteloua gracilis). The seed was applied by helicopter with an application rate of 9.63 lbs/acre (8.7 lbs/acre of which was pure grass seed). This application would average 50-60 seeds/square foot (538-646 seeds/sq m). The species were selected for 1) natural occurrence, 2) soil-holding properties, 3) availability of seed, 4) ease of seeding, and 5) the desire of the National Park Service not to introduce exotics. Although the Park Service does not normally advocate seeding of burned areas, the richness of the archeological resources and the potential loss of valuable information due to erosional effects led to the recommendation of the seeding. Because the majority of the acreage was severely burned, all of the burned area was seeded except a control plot of 180 acres on Department of Energy land.

Immediate post-fire seeding was delayed because of heavy rains; however, the total seeding of the area was completed by July 17, 1977, approximately one month after ignition.

Two types of plots were examined in this study. Prior to the La Mesa fire, areas of known fire history had been selected and phytosociologically sampled using a modified Lindsay line-strip

sampling unit 1000 x 20 feet, divided into 50-foot units each having a quadrat 1.0 x 0.5 m for seedling and herbaceous cover. These plots of known fire history were examined. In addition, immediately after the fire plots 20 x 50 m with herbaceous plots 0.5 x 0.5 dm had been placed in areas of severe, moderate, and light burn damage (Foxx and Potter 1978).

Relative foliage cover of species was determined in herbaceous plots and in selected areas density was determined by counting individual seedlings. Biomass studies were based on 10 quadrats 1 x 1 m clipped within 1 inch of the soil level, oven-dried, and weighed.

RESULTS

Germination of Grass Species

Slender wheatgrass and sheep fescue germinated the best of the six seeded grass species. Slender wheatgrass is a short-lived perennial which yields well up to five years and after that the production declines (Flory and Marshall 1942). It has 159,000 seed/lb of live pure seed (USDA 1948)(Table 1). Generally there was approximately 27% field germination of this plant species.

Sheep fescue is a fine-leaved and densely tufted perennial grass. It develops slowly but is very competitive with abundant roots. It has 680,000 seeds/lb of live pure seed (Table I). Average success of germination of this species was only 8%.

Other seeded grasses did not show significant germination 14 months after the fire. Western wheatgrass is a deep-rooted

Table 1. -- Numbers of seeds applied and expected germination based on application rate of 9.63 lbs/acre

Species	% Mix	Lbs/ acre [1]	Seed/lb (thous.)	Seed/acre (thous.)	Seed/sq m	Germ. %	Expected germ. seed/sq m
Agsm [2]	56.1	5.4	110	594	147	80	118
Agtr	19.6	1.9	159	301	74	85	63
Bogr	0.9	0.1	825	68	17	80	14
Feov	11.8	1.1	680	775	192	85	163
Muwr	1.0	0.1	2,424 [3]	240	59	80	47
Spcr	0.4	<0.1	5,298	196	48	80	38
Total	89.8	8.7	9,496	2,174	537		443

[1] Based on 9.63 lbs/acre as applied by helicopter

[2] Agsm (Agropyron smithii), Agtr (Agropyron trachycaulum), Bogr (Bouteloua gracilis), Feov (Festuca ovina), Muwr (Muhlenbergia wrightii), Spcr (Sporobolus cryptandrus)

[3] Muhlenbergia porteri, a related species

perennial with creeping rhizomes. It has 110,000 seeds/lb of pure live seed (Table 1). The new seedlings are small, single-stalked, and inconspicuous the first year but improve in density and vigor the second year (Flory and Marshall 1942). It spreads vigorously by rhizomes. There was only 0.2% germination within the first year.

Three species showed negligible germination, including blue grama, sand dropseed, and spiked muhly. Blue grama is a densely rooted shortgrass perennial which spreads by tillering. It has 825,000 seeds/lb. Sand dropseed is a pioneer or invader on raw denuded areas and especially on sand. According to Cassady (1937), scarification of the seed improves germination. The seed probably lies in the ground for a long time before it germinates. There are 5,298,000 seeds/lb. Spiked muhly, a perennial of coarse soils, also has very small seeds (a related species, Muhlenbergia porteri, has 2,424,000 seeds/lb).

Several factors were related to the success of germination of the seeded species, including native grass cover, pre-fire tree density, severity of scorching of the trees as related to fire history, and the presence of a pine needle mulch. These factors in turn are all interrelated.

The success of germination of the seeded grasses was inversely related to the amount of native grass which recovered rapidly and provided good ground cover in lightly burned areas. Figure 1 shows the relationship between the success of germination of two species of seeded grasses in relation to the amount of cover of native grasses which already had a good root mass and were well established.

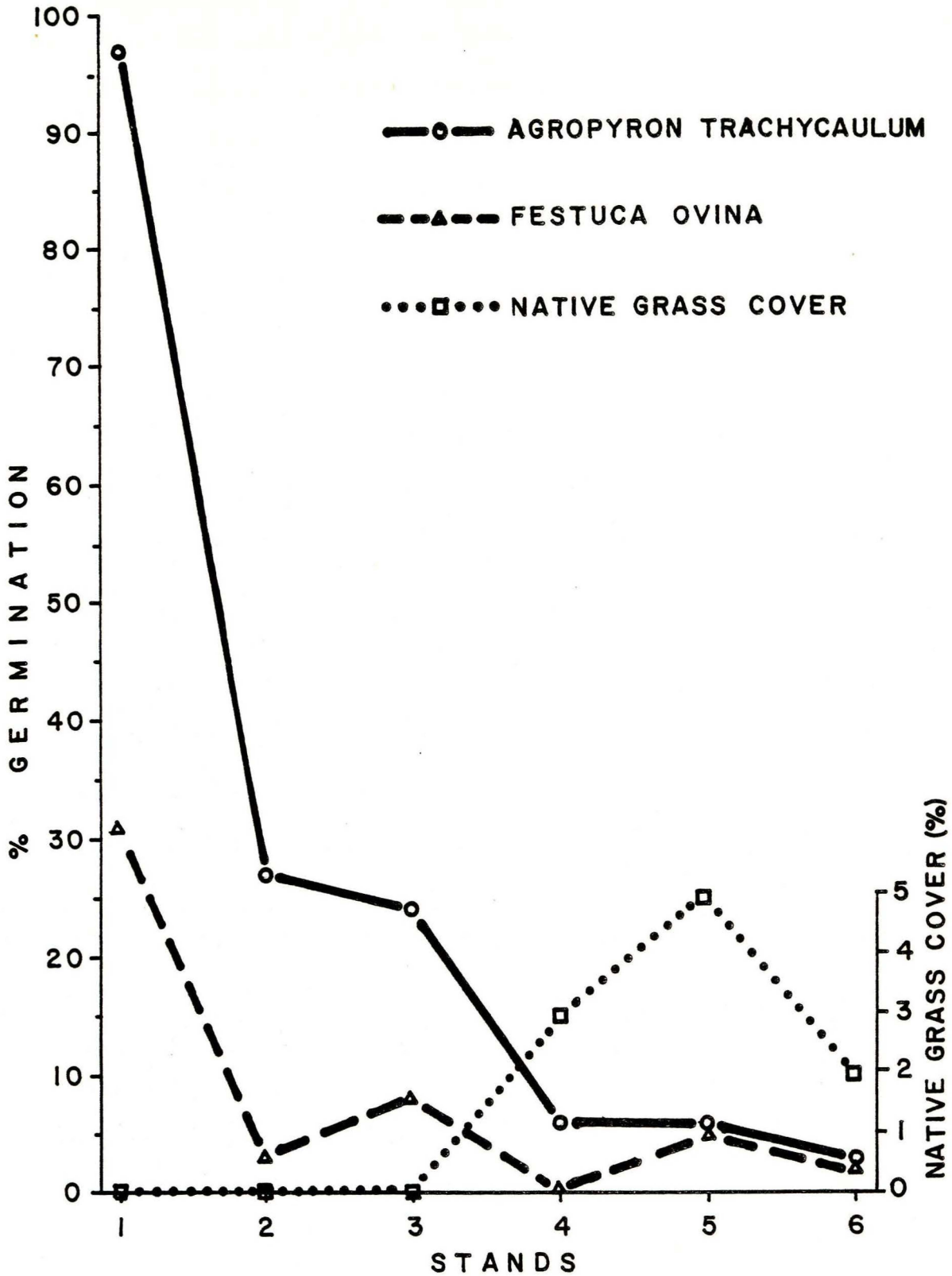

Figure 1. -- Comparison of percentage germination of slender wheatgrass (Agropyron trachycaulum) and sheep fescue (Festuca ovina) with cover of native grass species.

In areas where the native grasses were not destroyed and recovered rapidly after the fire, the seeded species did not germinate well. In areas in which the plots were virtually covered with native grasses, only in the severely burned pockets did the grass species germinate. This relationship is well illustrated in figure 2 where almost no seeded grass is present in the stand of native grass. However, in the area around the pine trees, formerly devoid of grasses because of the litter of pine needles, the grasses seeded into the ash following the fire show excellent germination and growth.

In figure 3 are illustrated several factors when the stands are arranged according to time since the previous burn. The best correlation is the inverse relationship between density of trees in the stand and the coverage and recovery of native grasses after the fire. In figure 4 the data indicate that, in general, the shorter the time between the La Mesa fire and the last previous fire the better the cover of native grass species, which would result in a less successful establishment of seeded grasses. The longer the length of time since the previous fire, the more severely the trees were damaged and this was reflected in the severity of burning of the understory and drying of the soils (Foxx and Potter 1978).

McConnell and Smith (1971) observed that litterfall on bared soil improved the production of hard fescue, while removal of all litterfall did not enhance production. At Bandelier two adjacent plots provide excellent contrast of the effect of pine needle fall upon grass seed germination. The first area,

Figure 2. -- Photo of success of seeded grass around base of burned trees versus lack of success in area of well-established, burned, native grass.

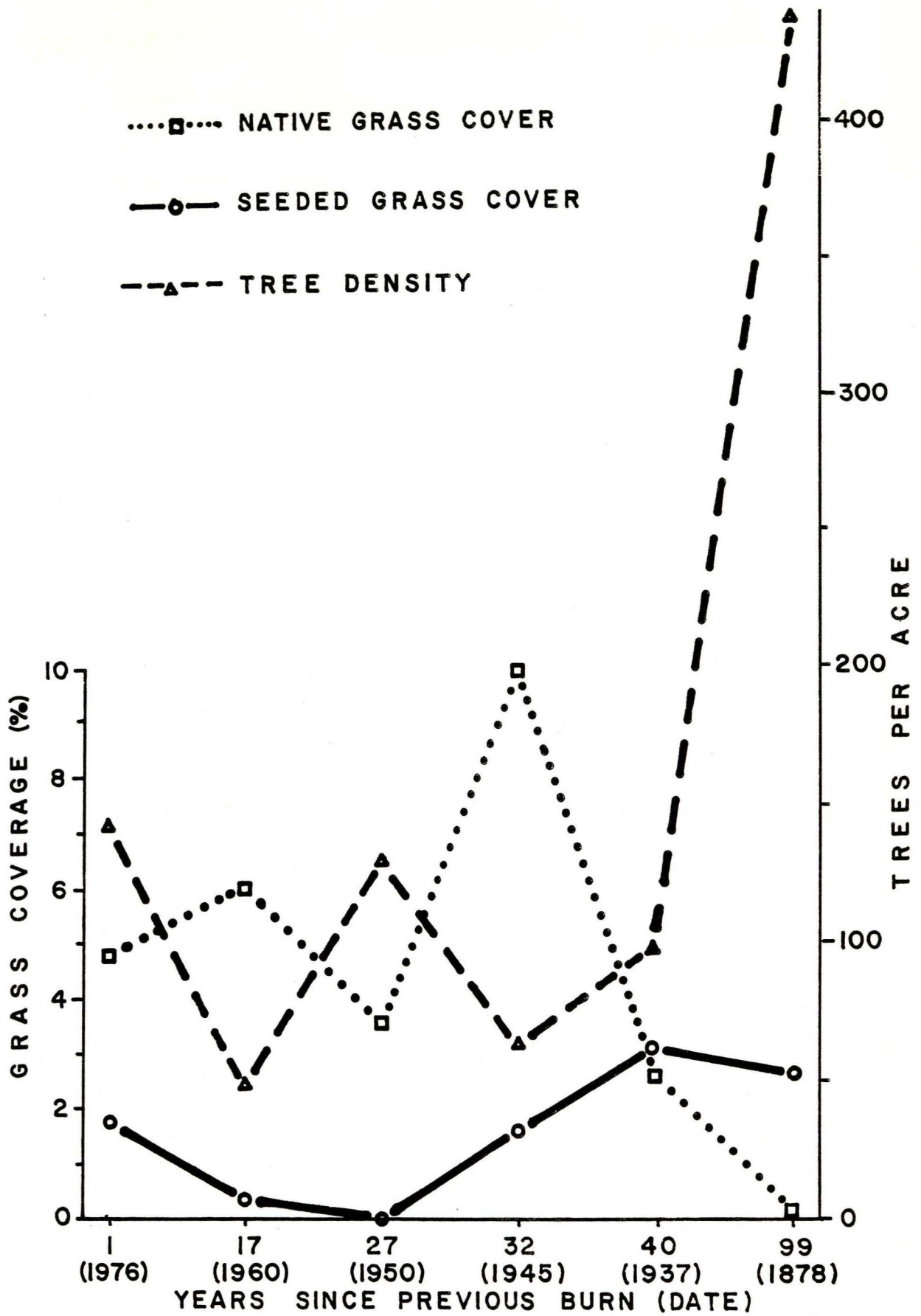

Figure 3. -- Comparison of percentage cover of native and seeded grass species with pre-fire tree stand density as related to fire history.

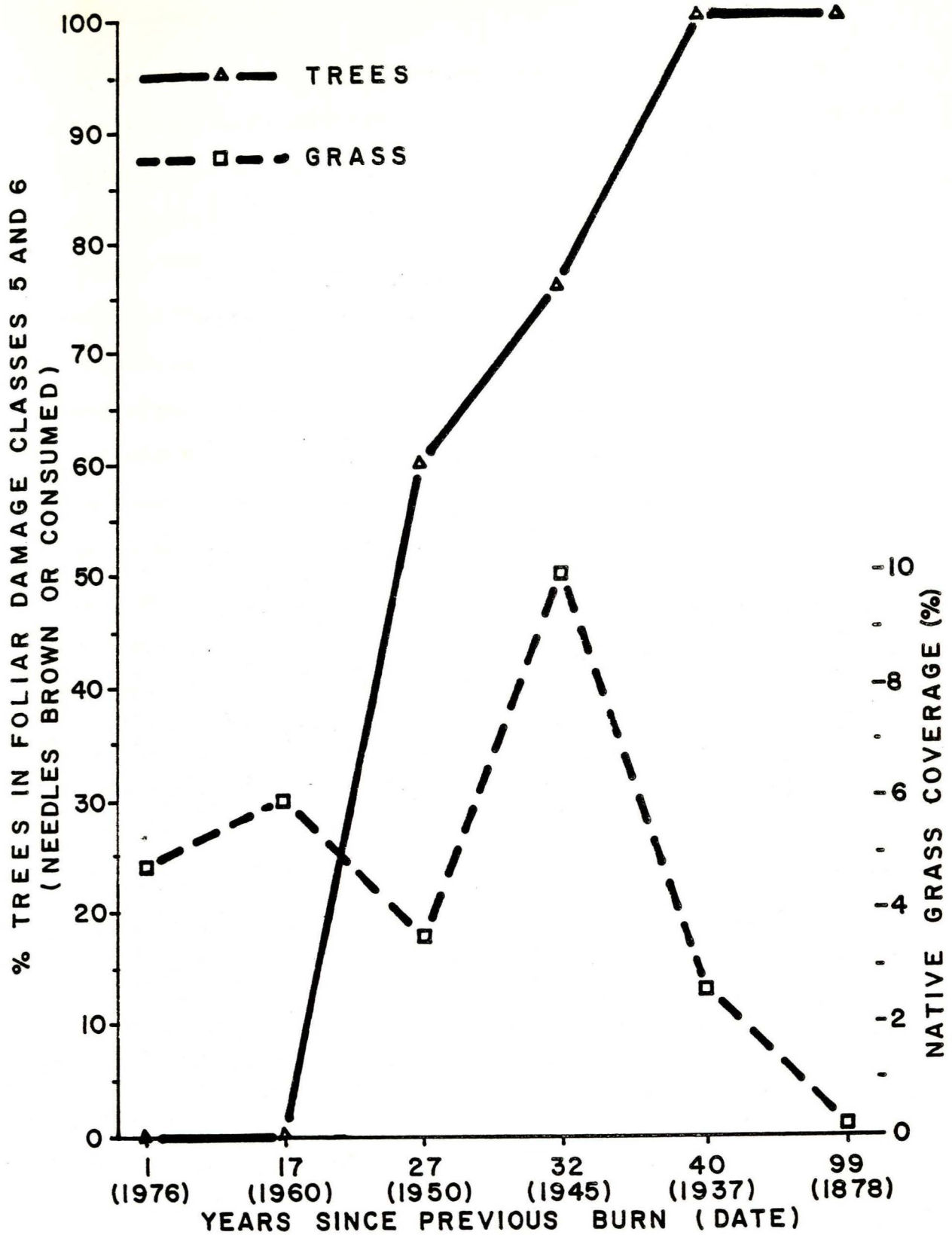

Figure 4. -- Comparison of the severity of burn damage to pine foliage with the recovery of native grass in plots not burned from 1 to 100 years prior to the La Mesa fire.

with 190 trees per acre, had been selectively logged some 60 years previously and most trees had over 50% of the crown scorched which resulted in a considerable amount of needle fall. The adjacent plot had not been logged and had 918 trees/acre. All trees in the latter area were killed and most needles were completely consumed. Measurements on September 27, 1977 showed that the success of seeding, based on the number of grass seedlings per average rate of seeding, was 52% in the area with needle fall while only 8% in the area with no needle fall (fig. 5A, 5B).

In June of 1978 (one year after the La Mesa fire) the examination of these plots was repeated and seedlings separated as to species. In the area where the needle mulch had been effective in holding the soil, preventing erosion, and retaining moisture and seeds, slender wheatgrass germinated at a 97% rate (Stand 1, fig. 1). In the area in which there was no needle mulch and the soil was not protected from erosion and seed loss, the success of germination was only 24% for slender wheatgrass (Stand 3, fig. 1). The same relative trends in germination rates were observed for sheep fescue (fig. 1). Stands without needle mulch had relatively low percentages of germination.

In a comparison of several different plots several factors were considered as principal causes of the relative success of slender wheatgrass. These included tree density and percentage of trees in various classes of foliar damage from the La Mesa fire. The best correlation was between the percentage of trees in foliar damage class 5 (all needles brown which would result in the maximum amount of needle fall) and the percentage germination

A.

B.

C.

D.

Figure 5.-- Comparative photos one year after the fire of seeded grass establishment on previously thinned plot which had a dense needle mulch (A) and adjacent, dense, unlogged plot where all needles were consumed (B). Two seasons after the fire the biomass and coverage of the needle-mulched plot (C) and the plot without needle mulch (D) were essentially the same.

of slender wheatgrass (fig. 6).

In contrast to the difference in germination percentages and resulting densities in the comparative plots, the biomass data are surprisingly very similar. The data of Table 2 indicate that in the Bandelier logged and unlogged plots the biomass weights of native grasses and Carex spp., reseeded grasses, and introduced grasses are essentially identical in the two plots. Even though there were 6.5 times more seedlings in the needle mulch area, after a year's time the fewer seedlings in the unmulched area had grown more robust so that total biomass was equal. This is an ecological tribute to the similar use of available nutrients by dissimilar densities of the same species. Interestingly, the balance was reached in approximately a one-year period. Not shown in the germination data of Table 1 is the coverage data, which was 13% in the mulched area versus 9% in the unmulched area (Table 2). The similarity of biomass and coverage is visually indicated in figure 5(c) and 5(d).

The La Mesa fire burned into the National Environmental Research Park of Los Alamos Scientific Laboratory. Within this area 180 acres were not reseeded. Comparative plots seeded and unseeded within the ponderosa pine zone were established (fig. 7). Plots in the seeded area were found to have 7% total foliage cover. Grass comprised 57% of the total foliage cover; 42% of the foliage cover was the seeded grass species, slender wheatgrass. In the unseeded plots there was an average of 6% total cover. Less than 1% of the cover was grass and over 99% was forbs. Chenopodium species made up 79% of the total foliage cover.

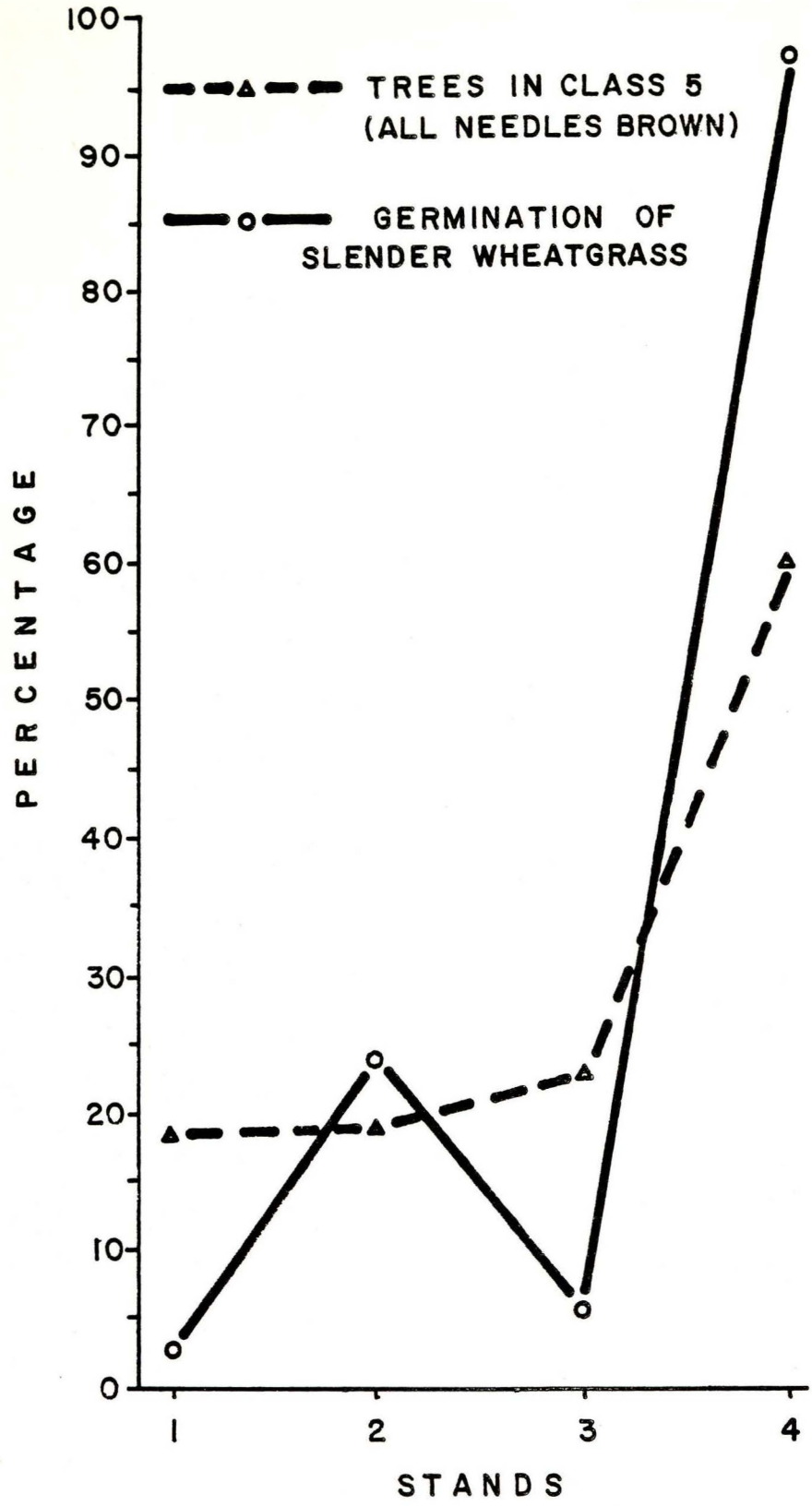

Figure 6. -- The relation of percentage of trees in foliar damage class 5 (all needles brown) and percentage germination of slender wheatgrass.

Table 2. -- Comparison of biomass of native grass, seeded grass, exotic grass, and forbs in five stands (based on ten subplots each)

	Grasses									Forbs			Total Biomass
	Native		Reseeded		Exotic		Total						
	g/m^2	% Grass	g/m^2	% Grass	g/m^2	% Grass	g/m^2	S.D.	% Biomass	g/m^2	S.D.	% Biomass	g/m^2
LASL													
Seeded	4.0	15	18.5	69	4.2	16	26.7	±2.4	31	58.4	±6.6	69	85.1
Unseeded	0	0	0	0	4.6	100	4.6	±1.0	6	76.4	±13.0	94	81.0
Bandelier													
Logged, needle mulch	0.2	<1	79.3	100	0	0	79.5	±5.4	100	0.3	±0.9	<1	79.8
Unlogged, no needle mulch	[1]0.1	<1	76.2	100	0	0	76.3	±6.1	100	0	±0	0	76.3
1960 previous burn	24.4	100	0	0	0	0	24.4	±0.7	84	4.6	±0.4	16	29.0

[1]Carex sp.

A.

B.

C.

Figure 7. -- Immediately after the La Mesa fire on Los Alamos Scientific Laboratory land (A); two growing seasons later on unseeded plot (B); and two growing seasons later on seeded plot (C).

Biomass in the seeded area amounted to 850 g/m^2 and in the unseeded area 810 g/m^2. Grass represented 31% of the total biomass on the seeded side whereas only 6% on the unseeded side. Forbs made up 94% of the total biomass on the unseeded side and only 69% on the seeded plots. Seeded grasses made up 69% of the total biomass on the seeded plots and 0% on the unseeded side.

When the total biomass of contrasting areas recovering from the La Mesa fire which were seeded versus unseeded and needle fall versus no needle fall are compared with an area in which native grass recovery was good (previously burned in 1960), the total biomass was nearly triple that of the predominantly native grass of an open pine stand having a good grass cover (Table 2).

DISCUSSION AND CONCLUSION

Bandelier National Monument is an area under the authority of the National Park Service. The philosophy is to let "natural processes" take place. The intention is to let natural recovery of pines occur. However, because soils are shallow and easily erodable and the precipitation pattern within the area is conducive to flash flooding, it appeared that seeding of the area was necessary to protect the archeological resources. Unfortunately, the high percentage cover of the grass is expected to affect the natural reproduction of pine. Many studies have shown that grass competes with pine seedlings for moisture, light, and nutrients. Also some grasses produce allelopathic substances which in turn inhibit the growth of pine seedlings. In areas

where there is an available pine seed source it is expected that the dense grass cover will adversely affect the already tenuous natural pine regeneration.

The density of seedlings of the seeded grass was inversely related to the amount of native grass which recovered after the fire. In areas where the pine stand was less severely burned the germination of the seeded grasses was considerably less. This was not just a function of the different rates of aerial seeding because within the lightly burned areas there were small pockets which were severely burned, or where bare soil was exposed by burning of needle mulch below trees, and in these areas seeded grass germinated well. The recovery of the native grass was inversely related to the density of trees in the stand, which in turn was directly related to the severity of fire damage. In the areas which had not burned for 80-100 years (several times the normal fire frequency of every 18 years), the tree stands were dense and little or no vegetation had grown under the forest canopy. In these areas the fire completely denuded the soil, rains caused compaction, surface runoff was serious, and much seed was washed away -- all resulting in a sparse establishment of seeded grass in comparison to areas in which the denuded soil was protected by needle mulch.

The germination of slender wheatgrass far exceeded all other grass species. In the unseeded plot Chenopodium species dominated cover and biomass. There may be several explanations. First, some grasses, e.g., foxtail (Hordeum sp.) produce allelopathic substances which check weedy species, such as Chenopodium

(Went et al. 1952). Second, the more extensive root mass of grass may compete for nutrients and water thus checking the growth of weedy species.

Western wheatgrass, although 56% of the mix by weight and the second most numerous seed, did not germinate well within the first year after seeding. It might be expected that this species will show better development in the second year. The rapid growth and density of slender wheatgrass and sheep fescue may also have competed with the slower growing western wheatgrass, thus suppresssing germination or seedling success of the latter.

Blue grama, spiked muhly, and sand dropseed showed negligible germination. This could be due to the small numbers of seeds applied or ecological factors such as soils, need for scarification of the seed, or competition with the rapidly growing slender wheatgrass and sheep fescue.

The percentage germination is based on an average application rate of 9.6 lbs of seed/acre. Various factors, such as washing of seed or uneven distribution of the application, could affect the total germination rate. This uneven distribution is reflected in the logged plot where a 97% germination based on average rate of application was observed, whereas the expected rate of germination based on seed testing was only 85%. In this logged plot any seed which was washed from adjacent areas would have been held by the needle mulch.

LITERATURE CITED

Cassady, J. T. 1937. Scarification of hard-coated grass seeds to increase germination. USDA For. Serv. SW Res. Note-13.

Earth Environmental Consultants, Inc. 1974. Soil survey and survey of range and ecological conditions on a southern part of Bandelier National Monument. Final Report, Nat. Park. Serv., SW Region, Santa Fe, N.M.

Flory, E. L., and C. G. Marshall. 1942. Regrassing for soil protection in the Southwest. USDA Farmers' Bull. No. 1913. U.S. Govt. Printing Office, Wash., D.C.

Foxx, T. S., and L. D. Potter. 1978. Fire ecology at Bandelier National Monument. Final Report, Nat. Park Serv., SW Region, Santa Fe, N.M., 214 p.

McConnell, B. R., and J. G. Smith. 1971. Effect of ponderosa pine needle litter on grass seedling survival. USDA For. Serv. Res. Note PNW-155, 6 p.

Tiedemann, A. R., and G. O. Klock. 1973. First-year vegetation after fire, reseeding, and fertilization on the Entiat Experimental Forest. USDA For. Serv. Res. Note PNW-195, 23 p.

USDA. 1948. Grass: The Yearbook of Agriculture, 1948. U.S. Gov. Printing Office, Wash., D.C., 892 p.

Went, F. W., and G. Juhren, and M. C. Juhren. 1952. Fire and biotic factors affecting germination. Ecology 33:351-364.